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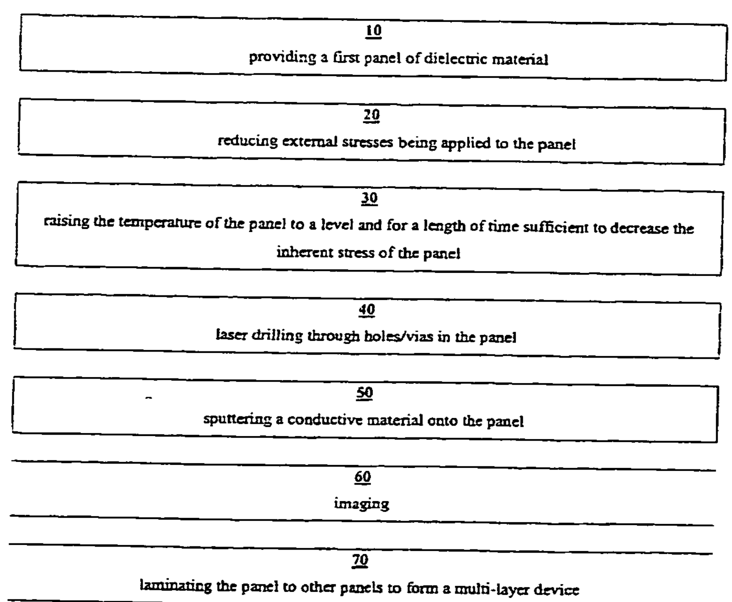
(54) Title: REMOVING INHERENT STRESS VIA HIGH TEMPERATURE ANNEALING



(57) Abstract: Methods and apparatus are provided which decrease the amount of movement likely to occur during processing of a substrate. In particular, a horizontally supported dielectric panel is subjected to a series of processing steps during which the panel is heated, cooled, or maintained at a fixed temperature so as to a achieve a 2 to 1 reduction in material movement during subsequent processing. It is contemplated that application of the disclosed methods to a dielectric panel will be particularly beneficial when application is accomplished prior to laser drilling and sputtering the panel.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

REMOVING INHERENT STRESS VIA HIGH TEMPERATURE ANNEALING

Field of The Invention

The field of the invention is substrate processing.

Background of The Invention

When subjecting thin polymer substrates used in the fabrication of IC packages, printed circuit boards, and multi-chip modules to processing steps which raise the temperature of the substrates movement of the substrate material will frequently occur. Such movement can cause difficulty in positioning and aligning of components during processing.

As an example, in a polyimide film substrate having lased vias, the position of the vias may change when the film undergoes increases in temperature. Such increases and resultant changes are likely to occur when a conductive material is sputtered onto the film. Thus, particularly in regard to dielectric materials, which are to be subjected to sputtering and/or lamination, there is an ongoing need to improve processing to reduce the amount of material movement, which occurs during processing.

Summary of the Invention

Methods and apparatus are provided which decrease the amount of movement likely to occur during processing of a substrate. In particular, a horizontally supported dielectric panel is subjected to a series of processing steps during which the panel is heated, cooled, or maintained at a fixed temperature so as to achieve a 2 to 1 reduction in material movement during subsequent processing. It is contemplated that application of the disclosed methods will be particularly beneficial when application is accomplished prior to laser drilling, sputtering, and laminating a substrate.

Various objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

Brief Description of The Drawings

Fig. 1 is a diagram of a first method embodying the invention.

Fig. 2 is a perspective view of a substrate panel being supported by a glass ceramic plate.

Fig. 3 is a perspective view of a stack of substrate panels with each panel being sandwiched between glass ceramic plates.

Fig. 4 is a perspective view of a stack of substrate panels stacked in a manner providing separation between panel and plate combinations.

Detailed Description

Referring first to figure 1, a method for processing a substrate comprises: step 10, providing a first panel of dielectric material; step 20, reducing external stresses being applied to the panel; step 30, raising the temperature of the panel to a level and for a length of time sufficient to decrease the inherent stress of the panel; step 40, laser drilling through holes/vias in the panel; and step 50, sputtering a conductive material onto the panel; step 60, imaging, and step 70, laminating the panel to other panels to form a multi-layer device.

Step 10, providing a first panel of dielectric material preferably involves obtaining a roll of dielectric film and cutting the material into panels. Although rectangular panels are currently preferred, and panel shape or size may be used so long as subsequent steps can still be accomplished.

Step 20, reducing the external stresses being applied to the substrate preferably comprises (referring to figures 2-4) supporting the first panel 111 by placing it on top of a first substantially planar and horizontal supporting surface 112. This can be accomplished by laying the dielectric panel 111 on a glass-ceramic plate 112. Glass-ceramic provides a distinct advantage over other materials as a result of a its having a low coefficient of thermal expansion. Low thermal expansion allows it to be subjected to very high temperatures without causing distortion or changes to a substrate (e.g. polyimide film) which is in direct contact with the glass-ceramic surface. It is contemplated that supporting surfaces having a

thermal coefficient of expansion which is less than or equal to X parts per million wherein X is one of 17.5, 17, 12, 6.5, and 6 may be advantageously used. Another advantage of glass-ceramic is that it is able to withstand the severe temperature profile from hot to cold that is required in this process. It is contemplated that desirable supporting surfaces will be capable of withstanding temperatures between 100 and 400 degrees Celsius for a time period between one and twenty four hours. It is also contemplated that in less preferred embodiments the supporting surface may not be planar, may not be horizontal, may have a different coefficient of thermal expansion, may not withstand the temperature profiles described, and/or may not be made of glass-ceramic.

It is contemplated that the disclosed methods may be applied to simultaneously processing multiple panels. In such embodiments, several panels 111, 113, and 115 may be provided with each panel being supported by a glass-ceramic plate 112, 114, 116, 118 with the glass-ceramic plates being stacked on top of one another to form a stack 100 of panels and plates. Although it is preferred that one panel be placed on each plate, alternative embodiments may utilize larger plates or smaller panels such that more than one panel is placed on each plate. In stacking the plates, each of the larger sides of the panels may be in contact with a plate such that a pair of plates sandwiches all or substantially all of the panels. Alternatively, additional supports 120 may be provided such that a gap exists between a panel and any adjacent glass plate not providing support to the panel.

Step 30, raising the temperature of the panel/stack of panels comprises subjecting the stack of panels to a high temperature anneal cycle, the cycle comprising a series of processing segments wherein each segment comprises placing the stack of panels in an inert gas filled chamber for a fixed duration, with the gas having a temperature which is either maintained within a fixed range for the duration or which is adjusted upward or downward to a target temperature during the duration.

In preferred embodiments the panel(s) are placed in an oven containing a nitrogen atmosphere and subjected to the following: ramping the temperature of the gas up from an ambient/room temperature to 150°C over a period of 5 minutes; dwelling at 150°C for 60 minutes; ramping up to 375°C over a period less than or equal to 30 minutes; dwelling at

375°C for 4 hours; ramping down to 100°C or less, and subsequently removing the panel(s) from the oven once the oven and/or the panels of cooled down to a temperature less than or equal to 100°C. Use of the previous times and temperatures is believed to result in a 2:1 reduction in material movement.

It is contemplated that variations in time and temperature of processing segments may have a significant impact on the amount of reduction in material movement to be obtained. However, it is contemplated a panel's inherent stress can be reduced by any method which provides adequate support (i.e. support with minimal stress) during heating and which heats the substrate to a temperature at which the material softens. The actual temperature and time required will vary depending on the composition of the panels, but are contemplated as likely being between 100 and 400 degrees Celsius and between 1 and 24 hours.

As indicated by steps 40-70, the methods disclosed herein are considered to be particularly advantageous when subjected to subsequent drilling, sputtering, imaging and/or lamination steps.

Thus, specific embodiments and applications of dielectric processing have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

CLAIMS

What is claimed is:

1. Method of substrate preparation comprising:

providing a first panel of dielectric material;

reducing external stresses being applied to the panel;

raising the temperature of the panel to a level and for a length of time sufficient to decrease the inherent stress of the panel.

2. The method of claim 1 wherein reducing the external stresses being applied to the substrate comprises supporting the first panel by placing it on top of a first substantially planar and horizontal supporting surface.

3. The method of claim 2 wherein the supporting surface comprises a coefficient of thermal expansion which is less than or equal to X wherein X is one of 17, 12, and 6.

4. The method of claim 3 wherein the supporting surface can withstand a temperature of at least D degrees Celsius over a time period of at least T hours without being damaged where D is 400 and T is 24.

5. The method of claim 5 wherein the supporting surface comprises a glass-ceramic plate.

6. The method of claim 5 further comprising obtaining a second dielectric panel and supporting the second panel by placing it on top of a second substantially planar and horizontal supporting surface wherein a stack of panels is formed by positioning the second panel and supporting surface above the first panel and surface, and the step of raising the temperature of the substrate material comprises raising the temperature of the stack of panels to a level and for a length of time sufficient to decrease the inherent stress of the panels.

7. The method of claim 6 wherein the step of raising the temperature of the stack of panels comprises subjecting the stack of panels to a high temperature anneal cycle, the

cycle comprising a series of processing segments wherein each segment comprises placing the stack of panels in a gas filled chamber for a fixed duration, with the gas having a temperature which is either maintained within a fixed range for the duration or which is adjusted upward or downward to a target temperature during the duration.

8. The method of claim 7 wherein the high temperature anneal cycle comprises the following segments in the following order:

ramping the temperature of the gas up from an ambient/room temperature to 150°C over a period of 5 minutes;

dwelling at 150°C for 60 minutes;

ramping up to 375°C over a period less than or equal to 30 minutes;

dwelling at 375°C for 4 hours;

ramping down to 100°C or less.

9. The method of claim 8 wherein the stack of panels is removed from the chamber once the temperature of the stack of panels is less than or equal to 100°C.

10. The method of claim 9 wherein the gas is nitrogen.

11. The method of claim 10 wherein the dielectric material comprises of a polyimide or polyimer film.

12. The method of claim 11 wherein subjecting the stack of panels to a high temperature anneal cycle comprises placing the stack of panels within a infrared convection oven, the oven comprising the gas filled chamber.

13. The method of claim 12 further comprising laser drilling through holes in the panels after the anneal cycle is complete.

14. The method of claim 13 further comprising sputtering a conductive material onto the panels after the through holes have been drilled.

15. Method of substrate preparation comprising:

providing a plurality of substrate panels;

providing a plurality of separation plates having a coefficient of thermal expansion less than or equal to 6.5;

stacking the panels and plates together and subjecting the stack to a series of heating and cooling steps wherein the temperature of the stack is raised to at least 370 degrees for at least 3.5 hours, during the series of heating and cooling steps.

16. The method of claim 16 wherein at least a portion of the series of heating and cooling steps is performed while the stack is in an infrared convection oven.

17. A method of substrate preparation comprising:

providing a first panel of dielectric material;

subjecting the first panel to a series of heating and cooling steps to change the characteristics of the panel such that subsequent material movement at elevated temperatures is less than or equal to one half of what it would have been if the panel were not subjected to the series of heating and cooling steps.

10
providing a first panel of dielectric material

20
reducing external stresses being applied to the panel

30
raising the temperature of the panel to a level and for a length of time sufficient to decrease the inherent stress of the panel

40
laser drilling through holes/vias in the panel

50
sputtering a conductive material onto the panel

60
imaging

70
laminating the panel to other panels to form a multi-layer device

FIG. 1

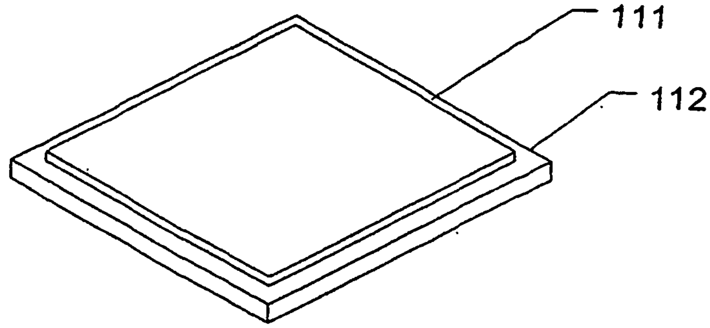

FIG. 2

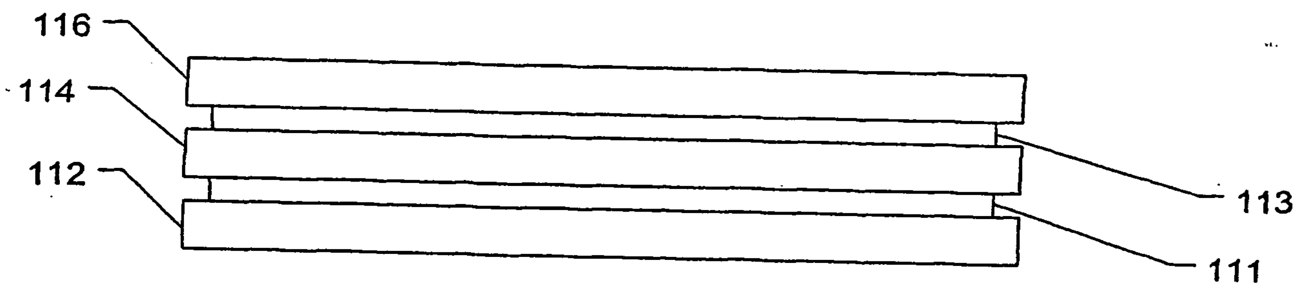

FIG. 3

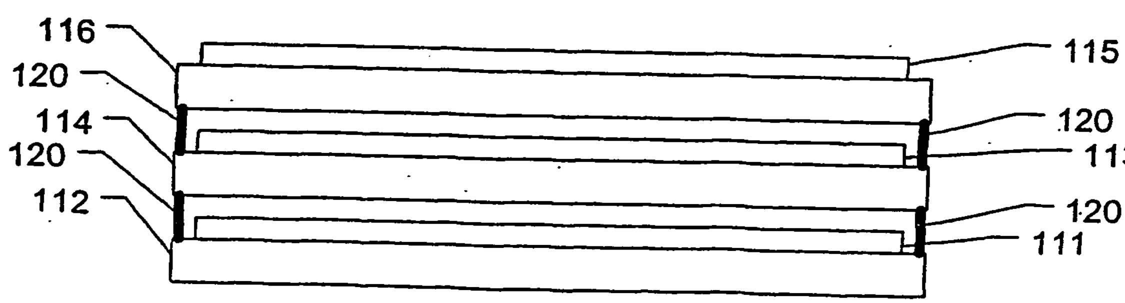

FIG. 4

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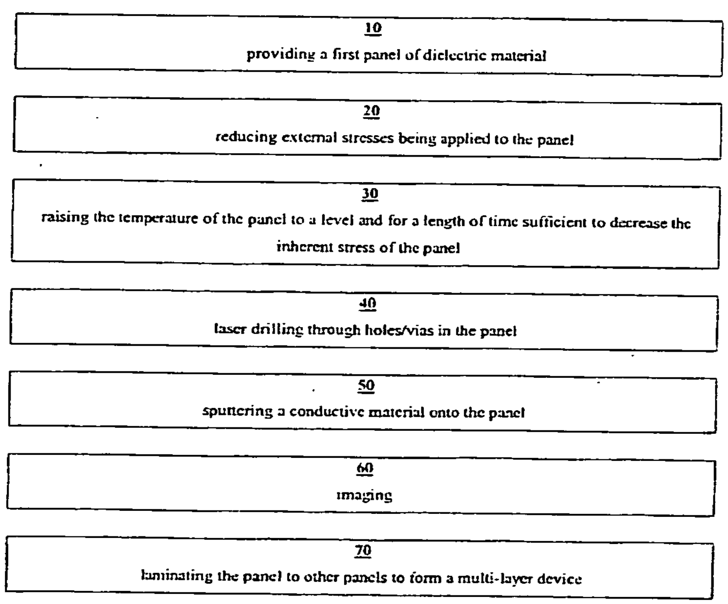

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ERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05K3/00 B29C71/02 C23C14/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05K B29C C23C C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X A	US 4 115 185 A (CARLSON ET AL.) 19 September 1978 (1978-09-19) claims ---	1,2,17 12,16
X	EP 0 196 874 A (ILLINOIS TOOL WORKS) 8 October 1986 (1986-10-08) claims; figures ---	1,2
X A	US 3 452 133 A (BRATTON ET AL.) 24 June 1969 (1969-06-24) claims ---	1 10
X A	US 3 988 408 A (HAINING ET AL.) 26 October 1976 (1976-10-26) the whole document ---	1 11
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 October 2001	25/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mes, L

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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ERNATIONAL SEARCH REPORT

.ormation on patent family members

Interr 'onal Application No
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